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EDITORIAL

THE IMPORTANCE OF BASIC KNOWLEDGE

In its structure and function the animal body is a triumph of Nature's creative art. The elaboration, assembling and co-ordination of all the various tissues in order that they may play their part goes far beyond any work of man. From the time when the two cells, male and female, coalesce, an ordered sequence of events is set in motion which is stayed only when death or disease supervenes.

In order to give of his best when dealing with animals either in health or disease, it is essential that the veterinary surgeon should have a sound basic understanding of the structure, function and development of the animals with which he is brought into contact. For this knowledge he looks to the anatomist. The anatomist, using the term in its widest sense, is privileged to make a critical and detailed study not only of the ultimate structure of an animal, but also of the creation of tissue, the assembly of that tissue into the various systems and component parts of the body, and of the co-ordination of the various parts and tissues which effect the perfect working of the living machine.

He can keep these processes under review from conception until death. It is obvious that many intricate changes occur in this period, and some are so intricate as to be revolutionary.

One of the most interesting of these changes occurs shortly after birth, when the circulatory system undergoes such changes as will allow of a state of independence in a body which up to that date has been entirely dependent upon another. Not the least of these changes are those which occur within the heart. There is a change in the cycle of circulation and also in its rhythm. In this switch-over of duty the foramen ovale is of prime importance. In fœtal life it is a bye-pass; in post-natal life this bye-pass must be closed. The fact that it is closed or sealed has been recognised since long before the time of Harvey. Its closure and the method thereof is indeed the foundation stone upon which the study of the neo-natal cardio vascular system is built. The method of closure varies in the different species and it would appear from a study of the literature on the subject that little precise attention has been paid to this process as it affects the larger domesticated animals. We have been content to surmise

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that the process must be similar to that which occurs in other species. In the article which we publish in this issue and in which the method of closure of the foramen ovale in the foal and calf is brought under review, the reader will appreciate at once that there are fundamental differences.

Research work of this nature is to a large extent academic, yet it is none the less of sound practical value, for it records an advance in basic knowledge. Such basic knowledge is essential to those who would make a study of the abnormal or diseased state. If we had a better knowledge of the normal then research into the problems associated with the abnormal state would be facilitated.

We therefore welcome such articles, especially when they come from the pen of a veterinary surgeon. We regret that, owing to war-time necessity, the article must perforce be published in two parts.

COLLABORATION

In the May issue of this Journal we were privileged to publish an article by one of our American colleagues. The subject was of great topical interest. In this issue we print an article from the pen of another of our American colleagues. His subject is also one of paramount importance, for there is no doubt that good health is dependent upon a good, balanced diet. In war time, with its shortages and distribution problems, a balanced diet is not attained easily and deficiency diseases come into their own. Taking the long view on this particular problem, it may be that war may do good, for necessity compels attention to a problem which to some extent is always with us and yet has not had the attention which it truly deserves.

In the future we hope to publish articles on a variety of subjects and from our American friends. In this way we hope not only to add to the store of knowledge but to foster and cultivate a collaboration with our comrades in arms that will endure and grow in time of peace and be of the utmost benefit to our profession and to our countries. We speak the same language; we have similar ideals; let us work together for the common good.

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General Articles

THE ANATOMICAL CLOSURE OF THE FORAMEN OVALE IN THE EQUINE AND BOVINE HEART: A COMPARATIVE STUDY WITH OBSERVATIONS ON THE FŒTAL AND ADULT STATES*—I

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Introduction

SINCE the time when a casual relationship between closure of the foramen ovale and the act of respiration was first suggested, efforts have been made to solve two outstanding and closely interrelated problems: the problem of functional closure and the problem of anatomical occlusion of the foramen ovale. Recently much has been advanced in respect of many previously obscure points connected with functional closure (Barclay *et al.* 1939, Amoroso *et al.* 1941 and 1942, Franklin *et al.* 1942, Windle 1940). Little, however, appears to be known of the steps involved in sealing the opening between the left and right atria in the equine and bovine heart.

The conception of anatomic closure of the foramen in domestic mammals is generally based on the condition as it occurs in the pig. In this animal (Patten, 1931) the foramen is an opening in the septum secundum. It is so situated that it is covered by, but not united to, the flap-valve of the septum primum which is situated to its immediate left. At birth, when the inter-atrial pressures are equal, it is simple to see that the foramen will become functionally closed, and with this condition established anatomical occlusion will follow.

In the equine and bovine hearts, however, the structural condition of the foramen and its valve do not admit of such a mechanism, since in these animals the valve is tubular, or nearly so, and attached all round the margin of the foramen (inter-atrial opening).

Historical

The study of cardio-vascular fœtal structures has engaged the attention of scientists throughout the ages. Prior to Harvey's momentous discovery of the circulation of blood in 1628, these observations were merely an accumulation of disconnected anatomical facts to which some attributed a function. But since his day structure and function have both entered the picture, and subsequent workers must have been encouraged by Harvey's work to study the pathway that made this circulation of blood in both the fœtal and adult states possible. Thus Richard Lower (1669) described two venæ cavæ and an interposed tubercle; while Wolff (1776), Kilian (1826) and Knabbe (1834) were more concerned with the division of the fœtal posterior vena cava into two channels, one such channel passing into either atrium. Wolff and Kilian also gave further details of the valve of the foramen ovale, and the latter recalled its resemblance to the finger of a glove in some species.

Bruch (1862) gave an account of the foramen ovale in man and the domestic

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mammals. He was concerned, however, primarily with contrasting the method of closure. In some species he described a reticular arrangement of the valve and suggested that closure might have been affected by collapse of this reticular formation; but he did not describe the associated anatomical changes, nor did he clearly distinguish between the pendulous valve of the equine and the fixed valve of the bovine.

Goubaux (1875) also referred to the reticular nature of the valve in the equine. He considered that the valve in the bovine was not attached all round the margin of the foramen ovale and, therefore, was not completely tubular in nature. He described cases of patent foramina in adult animals, but did not encounter this condition in the equine. Apparently this patency had little effect on the circulation of blood.

Frank (1883) gave a description of the valve of the foramen ovale; he considered its tube-like structure, the apical perforations and its freely-lying position in the cavity of the left atrium. He proceeded, however, to nullify all of this with the extraordinary statement that among the ruminants the valve is simple.

Chauveau-Arloing-Lesbre (1910) figured, but did not describe, the condition of the valve in a fœtal calf. In their figure the valve is shown as a semilunar membrane attached to the margin of the annulus vieussens.

Mosca (1914) gave a description of the valve in some of the domestic mammals. In his figure 1 of a bovine heart two-three days after birth it is evident that the valve has begun to be retracted and it shows quite clearly the incipient stages of closure in this species.

The disposition of the foramen and its valve in a number of Eutherian mammals has been described by Amoroso *et al.* (1941) and Franklin *et al.* (1940). These authors did not, however, deal with the process of closure.

Material and Methods

The material used for this investigation comprised a series of equine, bovine, porcine, feline and canine hearts of ages ranging from three-quarters of the way through the gestation period to well into adult life.

All were fixed in 5-10 per cent. formaldehyde solution. During dissection great care was taken to identify and note the orientation of vessels, particularly the pulmonary veins. In cases where the lungs were still attached to the hearts, as the pulmonary veins were cut their area of origin was noted.

The method of exposing the heart cavities was as follows: a longitudinal incision was made along the right wall of both the anterior and posterior venæ cavæ as far as the level of the tubercle of Lower. The roof of the left atrium was then removed by cutting along both edges from the cranial angle to the junction of the pulmonary veins. The relevant structures were then noted and packed if necessary. The final dissection consisted of " trimming " or sectioning the better to expose the structures for photographic purposes and for the observation of finer detail.

Terminology

A revised terminology has been suggested for the description of the fœtal heart and great vessels from a functional point of view (Amoroso *et al.* 1941

and 1942, Franklin *et al.* 1942). This nomenclature will not be used in full but reference will be made to the terms "fixed and apposable portions" of the foramen ovale and its valve as it is considered they more adequately describe the nature of these structures at least as they appear in the species under review. The term crista dividens will also be employed instead of limbus fossæ ovalis or annulus vieussens.

In the right atrium the posterior caval stream is separated cranially and dorsally from the anterior caval stream by the tubercle of Lower (inter-venous crest), the caudal part of which is an elevation on the inter-atrial wall extending from the free edge of the tubercle to the crista dividens. This elevation will be referred to later in greater detail. The term *atrial elevation* will be given to it.

Of the remaining features of the heart and lungs the terminology employed by Sisson (1938) will be used. In all cases structures will be described as in the living animal with the terms caudal, cranial, dorsal, ventral (sternal), right and left as indicating the three planes of the animal body.

The Nature of the Foramen Ovale and its Valve in the Fœtal Heart

Equine

The foramen ovale (the fixed portion), which is more or less rotund, is situated in the inter-atrial wall immediately to the left of and caudal to the crista dividens. Its valve (the apposable portion) is in the form of a membranous tube extending laterally across the cavity of the left atrium at right angles to the inter-atrial wall below the roof, and ventro-craniad to the passage of a group of pulmonary veins from the right lung. (See Fig. 1, A.P.) The distal portion of the tube—its apex—is usually rounded and always fenestrated, the proximal portion adjoining the foramen never so; thus it is usually possible to differentiate distinctly fenestrated and non-fenestrated areas. (See Fig. 1.) The walls of the valve are moderately thick and the diameter of its lumen is approximately the same as that of the foramen. Franklin *et al.* (1942) likened the valve to a worn-out finger-stall.

The thickness of the wall of the valve and the diameter of its lumen are subject to variations. There is no constancy in the size, number and position of the fenestrations. They are, however, always plentiful and confined almost exclusively to its distal end.

In the right atrium, the crista dividens is well developed and has a clear-cut sharp edge. The edge of the tubercle of Lower, which is separated from the crista dividens by the atrial elevation, is not yet fully developed. On looking along the posterior vena cava, the bifurcation of the two divisions of the posterior caval channel on the crista dividens is one of the most marked features of the fœtal heart.

Bovine

Fundamentally, the bovine fœtal heart exhibits the same general features of development as in the equine. The foramen tends, however, to be more oval; a feature more evident during the different stages of closure.

The valve is relatively longer, thinner and more delicate. The fenestrations are fewer, larger and nearer the apex; as a rule they are so restricted that they

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constitute a single large central lacuna fringed by a delicate fine-meshed network (see Fig. 2).

In the bovine the valve is not *so* freely-lying in the cavity of the left atrium as in the equine. It is anchored directly to the cranial wall of the atrium and is also restricted by cord-like muscular bands (see Fig. 2) similar to the "guy-ropes" figured and described by Franklin *et al.* (1940) in the sheep. In every case examined these cords have passed from the cranial portion of the wall of the left atrium to be attached to the valve close to, or actually at, the junction of the fenestrated and non-fenestrated portions. It has also been observed that the most distal loops of the fenestrations are often loosely attached to the atrial wall. In consequence of this anchorage the long axis of the valve is inclined cranially at a more acute angle to the caudo-cranial axis of the heart than in the equine heart.

In the right atrium, the crista dividens is equally prominent but has a rounded edge, while the tubercle of Lower is nearer to if not actually conjoined with the crista dividens, and this at the expense of the atrial elevation.

Anatomical Features Associated with the Functional Closure of the Foramen Ovale

It has long since been established that at birth as soon as the lungs begin to function the volume of blood passing to them will increase at the expense of the volume of blood passing through the foramen ovale. The volume of the pulmonary venous return will also increase. This will produce pressure on the valve from within the left atrium which will assist in functional closure. This pressure is concentrated, as more recently Amoroso, Barclay, Franklin and Prichard in a joint series of papers have shown that the relationship of some pulmonary veins to the foramen ovale and its valve is very intimate. In brief, they have shown that the group of veins draining the greater part of the right lung opens into the left atrium immediately dorsal to the foramen and its valve. Thus the venous return from these veins will impinge directly on the apposable portion of the valve, and increase in calibre of these veins can only be attained by decrease in calibre of the valve.

Moreover, it can be stated that during the greater part of fœtal life the small flow through these pulmonary veins courses more or less parallel with the flow from the right atrium along the lumen of the valve. As the fœtus develops and approaches full time, the pulmonary flow is directed more downwards on to the valve (apposable portion). This is presumably the time when the full effect of impingement referred to by Franklin *et al.* (1940) is observed.

Equine

The drainage of the pulmonary veins of the equine into the left atrium is of interest. It has been referred to by Franklin *et al.* (1942), but no details are given of anatomical dispositions. In the main they open by two common openings—the Caudal Opening and the Right Opening.

The caudal group opens into the roof, passing to the left of the posterior vena cava. Through it pass all veins draining the left lung and one large vein from the caudal third of that portion of the body of the right lung caudal to the heart (diaphragmatic area). Small veins from the cranial part of the body

and apex of the left lung may open independently cranial to this opening. The right group opens into the roof immediately dorsal and slightly caudal to the valve and is separated from the latter by its dorso-caudad wall only. Through it pass all remaining veins from the right lung.

Of the vessels entering the right opening (see Fig. 1), two small veins draining the apical region are closest to the valve; two others of approximately similar dimensions draining that portion of the lung covering the heart (often referred to as the cardiac lobe) open slightly ventral and caudal to the preceding; while two larger veins, one draining the intermediate lobe and surrounding region of the body, and the other the cranial two-thirds of that portion of the body caudal to the heart (diaphragmatic area) open immediately caudal to the former.

The individuality of this right opening with its well-marked oval margin and its propinquity to the valve of the foramen ovale cannot be over-emphasised. (See Fig. 5.)

Just prior to and for about six weeks after birth, when anatomic closure is being effected, another important structure becomes evident. It is a ridge interposed between the enlarging pulmonary openings and the apex of the closing valve. This ridge is formed by part of the wall of the valve. It is not very large in the equine and in adult life it merges with the ventral margins of the right pulmonary venous opening, the inflow from which is seen to play over it. It should be emphasised that this ridge is part of the proximal non-fenestrated area of the valve. It is the chief structure on which the pulmonary venous inflow will impinge to assist in functional closure—the term ***atrial ridge*** will be given to it.

Bovine

In the bovine the pulmonary veins also enter in the main by two common openings which are situated in approximately the same positions as in the equine heart. Through the caudal opening pass all veins from the following lobes: the greater part of the right diaphragmatic, left diaphragmatic, left cardiac, left apical. The opening thus formed is a relatively large one.

Through the right opening passes blood from the following lobes: right apical, right cardiac, with which is combined a vein draining the intermediate and small part of the right diaphragmatic. This latter vein may enter independently caudal to the vein from the right cardiac lobe. The opening thus formed is relatively small and more dorsal in position as compared with the corresponding opening in the equine heart, although it is still close to the valve.

The atrial ridge, interposed between the enlarging pulmonary venous openings and the apex of the closing valve, is much longer and directed at a more cranial angle than in the equine. Since the valve is anchored to the atrial wall the ridge still continues across the cavity of the left atrium in the right-caudal to left-cranial plane. In view of these changes in the orientation of and size of the ridge, i.e., the non-fenestrated part of the valve, it would appear that the greatest effects of impingement are produced by blood entering the left atrium from the caudal direction. Although there is no conclusive evidence to this effect, it is suggested by the fact that the atrial ridge is more in the line of

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blood entering the atrium through the caudal opening than the right opening. In the bovine there is relatively more blood entering the caudal opening than the right as compared with the relative amounts entering the caudal and right openings in the equine. If this is correct it lends support to the views advanced by Amoroso, Franklin and others that functional closure is assisted by impingement of proximate pulmonary veins.

Anatomical Closure of the Foramen Ovale

Throughout the greater part of fœtal life the structure of the foramen and its valve remains essentially as has been described above. It is only in the period immediately prior to and after birth that structural changes are encountered which herald the onset of functional and anatomical closure.

Equine

No definite time can be given for the initiation of these changes; but during the last month of ante-natal life the wall of the valve becomes slightly thicker and the fenestrations appear smaller. During the last week of pregnancy the apex of the valve elongates and the fenestrations constrict; this gives the apex an irregular outline which is often accentuated in the dead specimen by small blood clots. As this "crenating" process continues, the margins of the fenestræ begin, in places, to adhere and immediately before birth they become inverted to form a cicatricial-like mass, so that, at birth, the picture is that of a crenated net with the majority of its fenestræ partially occluded as a result of these adhesions. The crenated mass now appears to be supported by the non-fenestrated portion which has become slightly wrinkled, has assumed a more dorsal position and is brought appreciably nearer the foramen ovale. (See Fig. 3.) *It is at this juncture that the atrial ridge becomes evident as a structural entity.*

The patency of the valve at birth varies; most frequently the net appears completely collapsed; occasionally, however, a few of the fenestrations may remain unoccluded. This later feature may delay to some extent complete anatomical closure.

It must be emphasised that, while at this stage functional closure would appear to be complete, the growth of new tissue has not been extensive, since slight pressure with a probe suffices to break down these adhesions in the net. During the first few days after birth organisation of the crenated net becomes accentuated, the cicatrix thus formed becoming denser as the whole mass is progressively involved. The non-fenestrated portion is now even nearer the foramen.

At 15 days after birth the picture of the valve is that of a slightly wrinkled membrane—containing the atrial ridge, with a blunt cicatrised and now completely sealed apex, forming in fact the floor of the "fossa ovalis" as seen from the left atrium. (See Fig. 4.)

During the next 30-40 days further organisation takes place and at six weeks the valve as such has disappeared from the left atrium and is represented only by a slight elevation, on the "summit" of which is the now fully formed circumscribed cicatrix. (See Fig. 5.) At times the cicatrix is not as spherical

as is shown in this figure. If closely examined indications of the coiled net can still be seen. Throughout this period the pulmonary veins have been increasing in size and have contributed their part in the functional closure. (See Figs. 3-5, P.V.) The atrial ridge formed by the wall of the shrinking valve has also entered the picture. (See Figs. 3-5, A.R.) Though small in the equine, since the valve quickly recedes on the foramen, it is nevertheless of some functional significance (*vide supra*). With advancing age the cicatrix gradually contracts and becomes flattened, so that eventually the only representation of the valve in the left atrium is a cicatrix flush with the wall. (See Fig. 6, A.P.) As a result of these changes the foramen is occluded.

The changes associated with the formation of the fossa are best seen from the right atrium. Coincident with the changes occurring in the left atrium, the portion of the valve adjacent to the foramen is seen to narrow and shorten as a preliminary to the formation of the walls of the fossa and its long axis begins to turn cranially and dorsally. When closure is complete the fossa ovalis comes into being and is fixed in position; at first its apex is pointed, but as the cicatrix becomes organised it becomes more blunt. In the depth of the fossa there is a varying number of pectinate areas—the remnants of the cicatrix. These features indicate that the apex and walls of the fossa are formed by the remnants of the valve and its circumference by the fœtal foramen ovale or, according to the revised terminology (*vide supra*), they are formed by the apposable and fixed portions of the left terminal division of the posterior caval channel respectively.

The crista dividens is still a very prominent structure; its function as a dividing ridge is now diminishing at the expense of the tubercle of Lower which is coming into full functional activity.

Bovine

In the bovine, as in the equine, tissue changes are almost exclusively confined to the valve of the foramen ovale. Any differences in the method of closure are consequent upon variations in the structural features already noted, and also upon the varying relationships of the pulmonary venous openings to the valve.

It must be remembered that the valve is firmly anchored to the cranial atrial wall. During the last month of pregnancy its non-fenestrated portion becomes completely adherent to the cranial wall of the atrium along its whole extent. As this fusion proceeds the lumen of the valve narrows. The fenestrations now begin to adhere around their margins, thus initiating the formation of a cicatricial-like mass. This mass is not, however, as complete as in the equine at this stage, as the central fenestræ usually remain unoccluded. On account of its fixation to the atrial wall, the valve does not recede on the foramen and its long axis remains in the cranial direction. This progressive closure, accompanied by increase of the pulmonary venous return, is the state of affairs at or immediately after birth. Functional closure would now appear to be complete, and although the net is not as completely sealed as in the equine, this is compensated for by the longer, more narrow and fixed valve, or in other words—*by the nature of the atrial ridge.*

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The process of narrowing of the valve and the organisation of a cicatrix continues. At 20 days it is still possible to introduce a probe into the lumen of the valve from the right side, but the apex is now sealed. (Subsequent observations have indicated that the apex is not always completely sealed at this age.) At nine weeks the cicatrix, which had assumed a " rosette " appearance, is beginning to flatten out and a taut atrial ridge, as seen in the left atrium, " connects " it to the margin of the fossa ovalis. As life proceeds the cicatrix gradually flattens out and the ridge, though it can be identified as such for a much longer period than in the equine, becomes less evident.

As seen from the right side the fossa ovalis is gradually formed as changes in the valve proceed. The circumference of the fossa tends to become oval, then ellipsoidal, commensurate with these changes. The formed fossa is at first narrow and deep, no remnants of the cicatrised net are seen. The crista dividens varies little, the angle between the two channels it separates does not change.

(To be concluded.)

TUBERCULOSIS IN THE ANIMAL WORLD

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THE effect of animal disease on human tuberculosis is so obvious that it is of the utmost importance to note carefully all the various steps taken to get animal tuberculosis under control.

One thing is clear, tuberculosis can never be controlled in human beings unless it is first controlled among animals with which man comes into contact, and upon which he depends for part of his food; so that tuberculosis must be attacked not only among cattle, but also among swine and fowls. The medical profession should note that, in veterinary work, the X-ray has been found useless in detecting tuberculosis in its earliest stages. Both veterinary surgeons and doctors are apt to have either a grossly exaggerated idea of the dangers of the bovine tubercle bacillus to human beings, or they take the other extreme view and think it is of no consequence.

The late Dr. Stanley Griffith, who was one of our greatest authorities on human tuberculosis of bovine origin, once stated:

" Although in the population generally the mortality from all forms of tuberculosis has declined during the last half-century, yet among children tuberculosis in one form or another is still very prevalent, and is one of the chief causes of death and invalidism.

" The conclusions that may be drawn from the study of the anatomical situation of the primary lesions in relation to the type of infecting bacillus are as follows:

" (a) The path of infection of the bovine tubercle bacillus is, almost exclusively, the alimentary tract.

" (b) The chief port of entry of the human tubercle bacillus is the respiratory tract.

" (c) Primary abdominal tuberculosis, due to the human bacillus, is rare.

ABBREVIATIONS USED IN THE PHOTOGRAPHS

A.	Aorta.
A.P.	The valve of the foramen ovale, i.e., Apposable Portion of the left terminal division of the posterior caval channel.
A.R.	Atrial Ridge.
A.V.C.	Anterior Vena Cava.
A.Z.	The main vena azygos.
B.C.	Brachiocephalic artery.
C.T.	Chordæ Tendinæ.
D.A.	Ductus Arteriosus.
L.A.	Left Atrium.
L.P.A.	Left Pulmonary Artery.
L.V.	Left Ventricle.
P.A.	Pulmonary Artery.
P.V.	Pulmonary Veins draining through the right common opening into the left atrium.
P.V.1.	Pulmonary Veins draining the apical region of the right lung.
P.V.2.	Pulmonary Veins draining the cardiac region of the right lung.
P.V.3.	Pulmonary Vein draining the intermediate lobe and region of the right lung.
P.V.4.	Pulmonary Vein draining the cranial two-thirds of the diaphragmatic area of the right lung.
R.P.A.	Right Pulmonary Artery.

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FIG. 1.—Fœtal equine, about 320 days, caudo-dorsal view, roof of left atrium and caudal wall of the right pulmonary artery removed. To show the nature of the valve of the foramen ovale. Note the tube-like character of the valve (A.P.) and its fenestrated apex. Note also the dorso-caudal position of the adjacent pulmonary veins (P.V. 1, 2, 3, 4 rods inserted) relative to the valve of the foramen ovale. In this figure the letters A.R. indicate the site of the future atrial ridge.

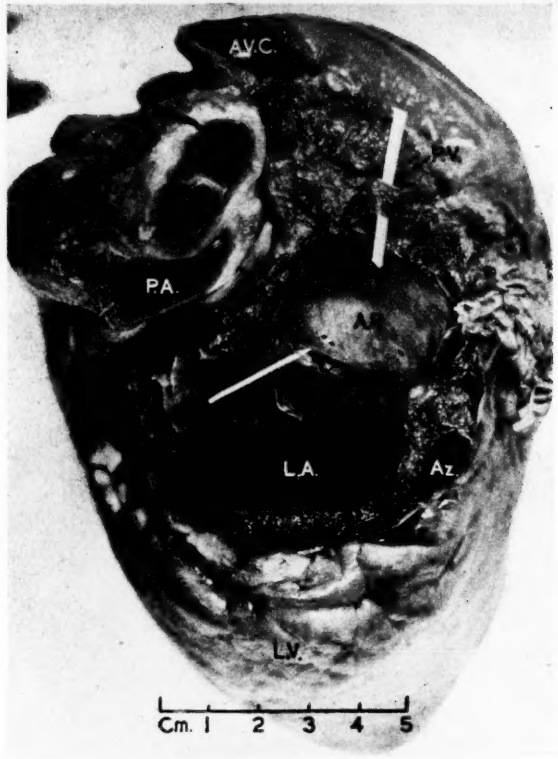

FIG. 2.—Fœtal bovine, about 240 days, left-caudo-dorsal view, roof of left atrium removed. To show the nature of the valve of the foramen ovale. Note the tube-like valve (A.P.) anchored to the cranial wall of the atrium (marked with an arrow) and the large central lacuna fringed by a network of fenestrations. The main azygos drainage (A.Z.) going to the coronary sinus *via* the right coronary vein is also shown. One rod is inserted into the pulmonary vein (P.V.) draining the apical lobe of the right lung and another rod can be seen projecting through the lumen of the valve.

the valve.

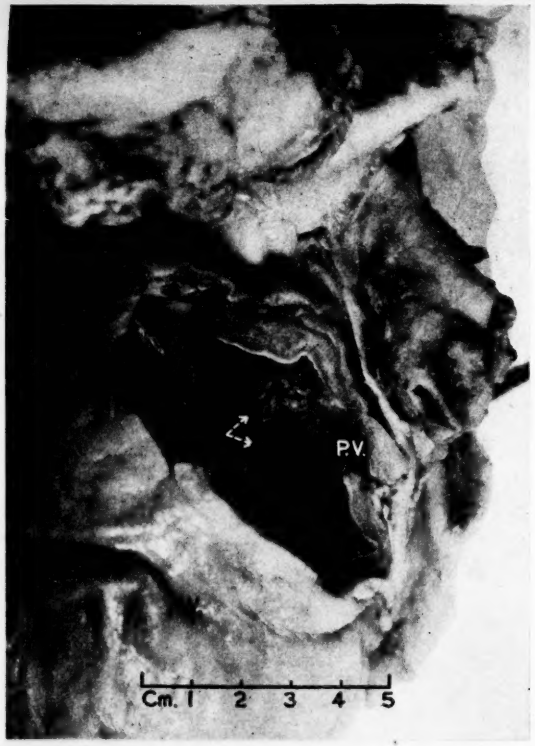

FIG. 3.—Equine, six hours after birth, caudo-dorsal view, roof of left atrium removed. The apex of the valve (A.P.) has formed a crenated net with the majority of its fenestræ partially occluded. The atrial ridge (A.R.), formed by part of the wall of the valve, is evident and part of the enlarging common opening of the right group of pulmonary veins (P.V.) can be seen on its immediate right. The valve has assumed a more ventro-dorsal position. Note the blood clots, marked with arrows, adherent to the lips of the crenated net.

FIG. 4.—Equine, 15 days old, caudo-dorsal view, roof of left atrium removed. A cicatrix has formed and the foramen ovale has closed. The atrial ridge (A.R.) is clearly shown. The right common opening of the pulmonary veins (P.V.) is now larger and its long axis is directed more caudally.

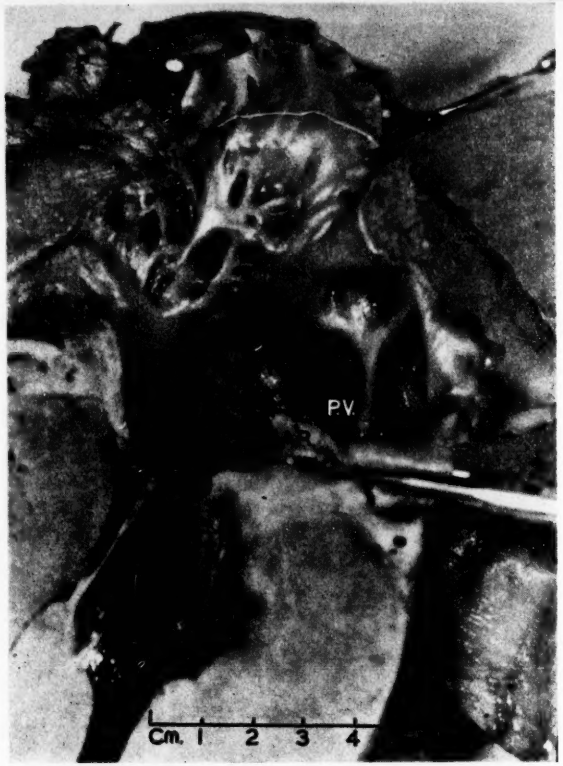

FIG. 5.—Equine, 4-6 weeks old, left view, roof of left atrium and left wall of left ventricle removed. The cicatrix (A.P.) is spherical and fully formed, although indications of the coiled net can still be seen. The atrial ridge (A.R.) is small. The right common opening of the pulmonary veins (P.V.) is large, note its well-marked oval margin identical with that in the fœtal heart.

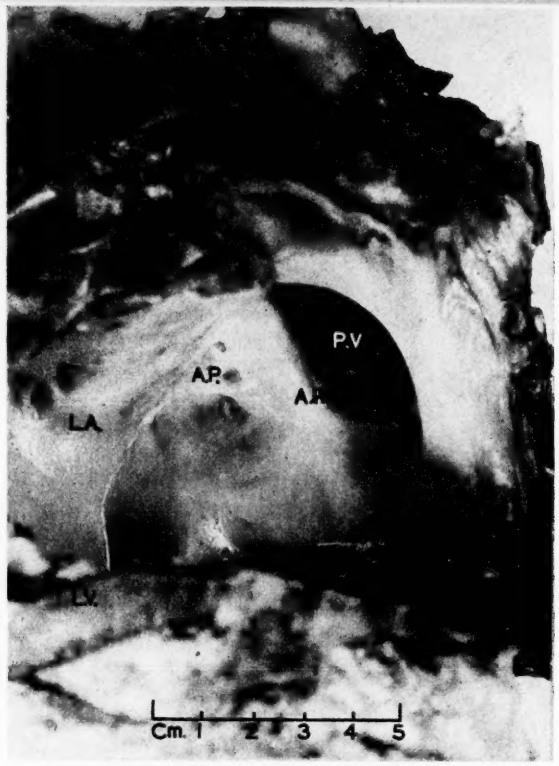

FIG. 6.—Equine, 3 years old,* left view, roof and left wall of left atrium removed. Between the 2nd month (Fig. 5) and 3 years considerable organisation of the valve has taken place. In this figure only a few reticular areas remain to mark the site of the fœtal valve (A.P.). The large pulmonary venous opening (P.V.) is on the right of the reticular areas, the two being separated by the remains of the atrial ridge (A.R.).

(*Although from an adult animal, the lettering is the same as for the fœtal heart in order to relate fœtal and adult structures).

"*Both bone and joint tuberculosis in this country are more frequently caused by human than by bovine bacilli.* Nevertheless the proportion of bovine infection is considerable, viz., 30 per cent. in children under five years of age and 23 per cent. in those from five to ten years.

"In genito-urinary tuberculosis, 19 per cent. of the cases, and in tuberculous meningitis, 16.6 per cent., were found to be infected with tubercle bacilli of bovine origin.

"The human tubercle bacillus is the more frequent cause of tuberculosis in children, and was found in 82.4 per cent. of an unselected series of children, under twelve years of age, who died from all causes.

"The highest percentage of bovine infection has been found in children under five years of age, and those forms of tuberculosis (cervical gland and abdominal tuberculosis) in which the primary lesions were in the alimentary tract. The age incidence, taken in conjunction with the anatomical distribution of the primary lesions, clearly points to cows' milk as the source of infection with bovine bacilli.

"Tuberculosis in cattle is as prevalent now as ever it was (*one in every three milch cows* is said to be tuberculous in some degree), and at the present day tuberculous milk is being sold for human consumption and is causing death and disease among children. It is desirable that this fact should be impressed on the general public, so that the administration may be stimulated to take action. The ordinary person does not, apparently, realise that raw cows' milk frequently contains living germs which may set up fatal or crippling disease in children.

"Tuberculosis is generally a slow developing disease. Many months may elapse before the consequence of ingesting bovine tubercle bacilli becomes manifest. These are not attributed, by the persons concerned, to cows' milk consumed months previously. Indeed, no one but the bacteriologist can decide whether or not a case of tuberculosis is due to infection with bovine tubercle bacilli.

"One can, however, hardly expect the general public to appreciate fully the danger of tuberculous milk until the medical profession itself becomes unanimous upon the desirability of attempting to eliminate all tubercle bacilli from the milk supply. There is not, however, the least evidence that the absorption from the alimentary tract of small numbers of bovine tubercle bacilli which have produced no lesions has a significant or lasting immunising effect. How can children be safeguarded against infection with tubercle bacilli, whether of the human or the bovine type? Tuberculosis of bovine origin in children can be avoided. If the milk is heated to 85 degrees C. for a few minutes in a closed receptacle the germs of the disease are certainly destroyed." Again, one must remember the danger arising from the consumption of butter and cream, which cannot be sterilised. "The only method of making the consumption of raw milk safe is by eradicating completely bovine tuberculosis. It is the conditions under which cattle are kept which foster tuberculosis, and if these conditions could be improved, thus diminishing the opportunities for infection, an increased racial susceptibility need not be feared. In this connection it may be mentioned that in the Channel Islands bovine tuberculosis has been stamped out and the cattle have remained free from tuberculosis for many years."

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The tuberculin test is the only satisfactory method in practice to-day. Periodic examinations are of very limited value, for diagnosis can only be made when the animal is badly infected, and by that time the casual organisms are being excreted, and probably have been excreted for some time. The tuberculin test will show that many animals which at the time of testing were not excreting tubercle bacilli, are classified as reactors and are treated as infected animals, as the risk of such animals becoming spreaders of infection is always present.

For a real effort to control tuberculosis in human beings, the medical profession can thus learn from the veterinary work, and in place of waiting till the X-ray shows distinctive disease in the lungs to rely on the tuberculin test for diagnosis. Mass X-ray, as now suggested, will only show doctors cases of pulmonary tuberculosis which their ordinary methods fail to recognise.

The following was the position as far back as 1895 :

(1) Tuberculosis of the lower animals is identical with human consumption.
(2) It is an infectious disease.
(3) The disease may be transmitted from man to the lower animals, and from the lower animals to man.
(4) Tuberculosis causes more deaths in the human family than any other disease.
(5) Cows are especially susceptible to the disease and are extensively affected by it.
(6) Milk from tuberculous cows may convey disease to the consumer.
(7) Milk from tuberculous cows, having non-affected udders, may convey the disease.
(8) The flesh of tuberculous animals may convey the disease.
(9) A large proportion of the cases cannot be recognised by clinical examination.
(10) No test yet discovered, other than that afforded by tuberculin, can detect any considerable proportion of cases in the living subject, and this test is practically infallible.
(11) Injections of tuberculin cannot produce tuberculosis, nor are the results harmful.

It is claimed that in the U.S.A. they have now carried out the eradication of tuberculosis among their cattle to such a degree that every herd in the country has been tested, and all but three states in the nation are on the modified accredited list. This work is claimed to be the most outstanding effort for the control of tuberculosis of both animal and man in the history of the world.

In the district of Columbia in 1909 some 1,700 cattle were tested with tuberculin, and 18.87 per cent. reacted. All reactors were removed from the herds, and methods of protecting the remaining uninfected animals were rigidly enforced.

No animal which reacted to the tuberculin test was allowed to enter the district. By 1922 the reactors had decreased to 0.17 per cent., and by 1925 there were no reactors.

In the States it was claimed that in the large cities, where pasteurisation

was enforced, the incidence of tuberculous lymphodes of bones and joints rapidly decreased.

In this country it should be illegal to put a reactor into a sale without disclosing the fact that the animal reacted to the tuberculin test. The reactor animal should be marked. Four different types of the tubercle bacilli exist: they are the human, the bovine, the avian and the piscine. Only the human and the bovine types are of interest in the study of human tuberculosis.

The human type of the tubercle bacillus is, however, capable of causing tuberculosis in most animals where they are domesticated, or are in captivity, or are artificially infected.

The bovine type of the tubercle bacillus is found in animals, but it infects man also. Some years ago the Ministry of Health stated that in this country more than 1,000 young persons under 15 years of age are killed each year, poisoned by the bovine tubercle bacillus. The main source of this poisoning is from milk. The Director of the Department of Experimental Pathology estimated that in England and Wales there were some 4,000 fresh cases of human beings infected with the bovine tubercle bacillus each year. Many of those infected persons remain invalids for long periods, and frequently those who recover are crippled.

As regards cases of tuberculosis among human beings, it has been thought that, provided there are only a small number of tubercle bacilli with each infection, the human body is capable of dealing with each such infection, and provided the individual is removed from the risk of further infection the disease will in time die out.

Years ago Robert Koch claimed that persons suffering from tuberculosis in its earliest stage were easily cured by the use of tuberculin. Here is a line of work to be carried out by veterinary research, to clean up both these points, and especially to discover whether there is any difference in the treatment of animal infection by the use of a tuberculin prepared from the bovine tubercle bacilli, compared with that made from the human bacilli.

The problem of the prevention of tuberculosis, with the object of reducing the risk of consumption developing, on a child reaching adult life, is being attacked in the animal world, and should be followed by the medical profession. We cannot carry out experiments on human beings, but we should learn from veterinary work and use that experience. We should study the problem of immunity and try to discover its secret. To what is it due? Is it a substance and, if so, where is it produced, and where is it stored, ready for use, immediately it is wanted? To take an example of what is wanted, the cat, as far as is known, is immune to infection by the human type of tubercle bacillus, and if we can learn the reason for this apparent immunity a great step forward could be made. Again, is it true that certain animals are immune to infection from foot and mouth disease and, if so, to what is that immunity due? It is thought by some that iodine in the body has a great deal to do with those animals' immunity to infection. What is its influence on animal tuberculosis? Many observers considered that infection with the bovine type of tubercle bacillus, in the case of human beings, tends to produce a more chronic state of disease, and that in those persons the lungs are not so often attacked. This needs careful investi-

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gation, for if we could produce evidence that one type of bacillus infection in an animal does materially influence the course of tuberculosis caused by the other type we should have opened a new method of controlling animal tuberculosis. A calf is very liable to be infected by the bovine type of bacillus, and if one could show that infection with the human type of tubercle bacillus caused a very mild infection, and rendered that calf immune to infection by the bovine type, this would be vital information of the highest degree.

To-day, very striking results have been produced with B.C.G. Animals treated regularly with B.C.G. resist, to a marked degree, infection in herds in which "open" cases of tuberculosis are present.

The Vole acid-fast organisms, isolated by Wells, and experimented with by Wells and Brooks, who consider that the Vole bacillus gives a degree of protection far greater than that by other means, have many features common to tubercle bacilli. It may be that in the Vole organism we have a product which may prove of great help in the control of bovine tuberculosis. The work carried out by Cambridge Institute of Animal Pathology has been of great interest. The strain of B.C.G. used would appear to be avirulent for the calf and incapable of giving rise to progressive tuberculosis, even when inoculated in large doses. B.C.G. can raise the resistance of a calf to avirulent experimental infection. Intravenous injections have proved to be the most satisfactory method of vaccination with B.C.G. The medical profession should take note of the experiments on calves which, after two series of vaccinations at three-month intervals, were tested at the end of six months by the oral administration of a large dose of virulent bovine culture. At the end of a year these calves were killed. All were found to be free from visible lesions.

It is interesting to compare the diseases transmissible from cattle and other animals to man, such as anthrax, glanders, rabies, Bang's disease and tuberculosis; and the reverse, namely, from human being to animals, diphtheria, septic sore throat, scarlet fever and tuberculosis (human type). The menace to man of avian tuberculosis is comparatively slight. Tuberculosis of human origin is rare in many animals. The cow, horse, dog, goat, cat and rabbit are difficult to infect artificially with this type of organism, even when injected under the skin. In conclusion, one can safely say that the medical profession is, on the whole, quite ignorant of the very valuable work which has been done in the veterinary world and should make more use of the results obtained, and that both the medical and veterinary professions should jointly press the Government to attack the problems of the prevention of tuberculosis, both among human beings and among animals, in a truly national effort and not, as to-day, at the expense of the farming community.

The example quoted of what was carried out in the District of Columbia should be copied here in this country by the Government, taking first one county and then another, until no reactors are found, while at the same time research should be pressed forward to discover some other means of controlling the disease, such as by inoculation with B.C.G. or other vaccine. There has been some interesting work carried out in Switzerland on the control of disease by using the blood of an animal which was immunised to that particular disease, and that method was modified and used as a means of preventing colds in human beings

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with a considerable amount of success. In this case the idea was to increase one's power of resistance, but this was not permanent in duration and lasted as a rule for about four months, but it was a definite step in the right direction, and further work along these lines is being continued.

Recently in the House of Lords it was urged that there should be an inquiry into the condition of the soil and its bearing on animal diseases, and also on the question of the fertility of both animal and human life.

Finally, the two professions should urge the need for a real national effort to get tuberculosis in cattle under control, and also among swine and fowls, and, if it is true that tuberculosis is becoming more common among sheep, that should also be taken in hand.

SOME THOUGHTS ON SWINE NUTRITION, WITH SPECIAL REFERENCE TO COMPONENTS OF THE VITAMIN B COMPLEX

By A. H. QUIN, D.V.M.,

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INCREASING research reports and field observations indicate the importance of vitamin B complex elements in maintenance of swine health and the relation of their deficiency to characteristic pathological conditions.

Much of this information is not as yet well correlated relative to quantity and quality of diet, predispositions to deficiencies, optimum intakes for normal metabolism, adequacy of intestinal synthesis, and relationship to bacterial pathogens.

Like men, swine are omnivorous animals, and as such require more complex nutritional essentials than do the herbivores, especially in respect to proteins, essential amino acids, vitamins, and mineral elements. A further factor to consider is that swine, under the environmental and feeding conditions of modern husbandry, are forced from a birth weight of a single pound or two to marketing weights of 250 to 300 pounds within a period of months rather than over the period of years normal to this species in its wild state. There is ample room for conjecture and doubt as to whether or not organic efficiency has kept pace with specialised breeding centred on quick growth and ability to lay on fat.

One fact above all is exemplified by day-to-day experience, namely, that any inadequacy of essential food elements in such rapidly growing animals is quickly reflected by marginal or clinical symptoms of deficiency diseases. Of these, the pathological entities traceable to deprivation of proteins, vitamin A and vitamin D are exemplary. The phenomenally severe copper-iron deficiency anæmia of young pigs having no contact with earth is suggestive. Also, under the new-type sanitary husbandry of raising pigs on cement floors, deficiency troubles associated with deprivation of earthy trace elements—cobalt, iodine, copper, manganese, etc.—are increasingly apparent.

On most farms in the hog belt, swine feeding from birth to maturity follows a more or less routine pattern. In general, this embraces a supply of grains,

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largely corn, usually home-grown, with protein concentrates of vegetable and/or animal origin, access to pasture, except during the fattening period, and a mineral mixture. Such feeding schedules have, by trial and error on millions of animals, proved satisfactory for quick gain and ability to fatten.

Insufficient and often conjectural opinion exists as to whether usual swine rations supply an optimum daily intake of all essential vitamins. It is reasonable to assume that pigs ranging legume or blue grass pasture obtain sufficient vitamin A. Also that range-raised pigs exposed to summer sunlight and with access to a simple mineral mixture run little risk of D type avitaminosis. But, when vitamin B complex and vitamin C are brought under discussion, such discussions are usually dismissed with the trite statement that: "Swine synthesise these vitamins in the intestinal tract."

Granting that this is true, and research offers verification, do we know under what conditions this synthesis may be impaired? Can we evaluate the relationship of intestinal parasites or bacterial enterites to such synthesis? Can we postulate the amounts of vitamin B complex needed in the ration to supplement intestinal synthesis in so rapidly growing an animal as a pig? How long before vitamin-synthesising bacteria are established and effectively active in the sterile digestive tube of newborn pigs?

These and many other questions must be clarified by future controlled research. In the interim, there remain the economic problems that may mean profit or loss, good growth or poor, health or disease, in the average herd of the average farmer.

Thiamin

Thiamin or vitamin B_1 is not stored in the animal body. The optimum daily requirement for a growing pig is high from a unitage or milligramage standpoint. It is wholly essential for proper metabolism of carbohydrates. Corn, the seed grains, and milk fortunately contain considerable amounts. Deficiency may be reflected by symptoms of anorexia, nerve pathology and cellular degeneration of the myocardium (so-called flabby hearts).

Riboflavin

Riboflavin or vitamin B_2 is none too plentiful in grains and dry pasture grasses, although milk and buttermilk contain considerable quantities, as do tankage, peanut meal, whey, liver meal, etc. Further, it seems a fortunate provision of nature that intestinal bacterial synthesis of riboflavin is more ample than some other elements of the B complex. Riboflavin, too, appears to have a sparing effect for certain other vitamin elements.

When inadequacy is marked, the deficiency may be reflected in the pellagra-like syndrome characterised by ocular lesions, stomatitis and glossitis, poor tone of the gastrointestinal mucosa, and dermatitis.

Niacin

Preliminary reports that uncomplicated niacin (nicotinic acid) deficiency is the causative factor of necrotic enteritis in swine appears in error. However, the work of Chick, Rose and Martin[1], of Davis, Freeman and Madsen[2], the field observations of Hawthorne, Hastings and others, amply verify that niacin

is a wholly essential food factor for swine and that frank deficiency of this element—a not uncommon occurrence under ordinary farm conditions—predisposes to intestinal pathology and to a pellagra-like disease of young pigs, usually from 3 to 12 weeks old.

The point too often missed is that when niacin is lacking all or several other component elements of the B complex may also be missing. Hence, we often encounter multiple vitamin deficiency rather than a single avitaminotic entity.

It is likewise logical to conclude that while niacin deficiency predisposes to intestinal infection, gross parasitism and intestinal infection also predispose to niacin deficiency because of lowered food utilisation efficiency. In other words, a vicious cycle is established.

Pantothenic Acid

Reports by Hughes[3], Hughes and Ittner[4], and more recently by Wintrobe *et al.*[5], clarify the nutritional requirements of swine for pantothenic acid and clearly outline the clinical symptoms and pathology of this specific avitaminosis. Thus, Hughes described "goose-stepping," poor co-ordination, slow growth, partial or complete loss of hair coat, and variable gastrointestinal involvement. The California workers set the minimum requirements of pantothenic acid for growing swine at from 8 to 12 milligrams per hundredweight daily.

Very recently, Wintrobe[6] and his co-workers have published a comprehensive report on pantothenic acid deficiency among swine on purified diets. In large part, their data substantiate previous observations.

Their findings are summarised by the statement: "Pantothenic acid deficiency in the young pig is characterised by diarrhœa, then dysentery, loss of appetite, very marked impairment of growth, loss of hair, cough, excessive watery nasal secretion, changes in the tongue, and abnormal gait."

Intestinal pathology ranged from diffuse hyperæmia, increase in size of lymphoid follicles, and formation of small ulcers, to extensive inflammatory changes involving the large intestine.

The deficiency was also accompanied by a moderate normocytic anæmia.

"The administration of 500 or more micrograms of calcium pantothenate per kilo of body weight per day was accompanied by cessation of diarrhœa, gradual improvement in the condition of the bowel, a restoration of normal blood values, growth of hair, and gain in weight."

Pyridoxine

In contrast to uncomplicated pantothenic acid deficiency, pigs kept by Wintrobe *et al.*[7] on purified rations deficient in pyridoxine (B_6) developed marked, rather than moderate, anæmia. Other symptoms and lesions included convulsions and epileptiform seizures, anorexia, demylenisation of nerve sheaths, fatty degeneration of the livers, ataxia, etc.

Other Components

The role of other components of the vitamin B complex, including biotin, folic acid, inositol, and possibly others, in normal swine metabolism and pathology await future amplification by controlled research.

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The author recalls a heavy loss of swine kept on an almost exclusive ration of cracked eggs. Liver pathology was predominant. In the light of present-day knowledge it appears logical that the loss was due to biotin deficiency precipitated by gross intake of the biotin-destroying egg-white factor or so-called avidin.

Treatment of swine enteritis with sulpha drugs is increasingly common. We might well keep in mind that prolonged intake of sulphonamides may precipitate folic acid deficiency with resultant anæmia.

Conclusions

Summarised, an inadequate or frankly deficient intake of vitamin B complex may result in pathological symptoms among swine. Such deficiencies may appear at any age, but are more likely to appear near weaning time or soon after. Symptoms of poor growth, dermatitis, ataxia, inco-ordination, anorexia and variable enteritis among swine may be directly associated with a B complex type avitaminosis, especially when protein intake and sanitary environments are normal. Gross parasitisms may predispose swine to B-type avitaminoses. Average swine rations, more particularly those heavy in corn, for growing pigs, may not supply optimum amounts of B complex.

The use of brewer's yeast, liver meal, dried whey, milk and buttermilk, alfalfa and alfalfa leaf meal for growing pigs, appears profitable from a nutritional standpoint. In clinical deficiencies, large daily doses of brewer's yeast and synthetic vitamins of the B complex are well indicated.

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Clinical Cases

ARSENIC POISONING IN CATTLE

By CHARLES WEIGHTON, M.R.C.V.S.,
Lincoln

On the evening of October 20, 1943, thirty-five Lincoln Red store cattle in forward condition were turned into a field following a drove of some seven or eight miles. They were seen to make straight for a trough and drink eagerly. The trough had not been cleaned out since sheep were dipped in it the previous summer, and contained an arsenical dip as it was at the time of

dipping with the addition of the autumn rainfall. Two bullocks were found dead in the crew-yard next morning. Two were very ill and were down and unable to rise. Both animals died on October 22, 1943. Another bullock died during the night of October 22-23. By the 24th another two bullocks were found down; one of these showed signs of scouring the day before. Both were dead on October 25, making a total of seven deaths within five days. On October 23 eight bullocks of the remaining 30 were seen to show symptoms of poisoning. Two strained at intervals and passed small quantities of normal fæces. Three showed dullness only, while three were salivating although otherwise not obviously disturbed. Sweating appeared in practically every case in the latter part of the illness. There was no sign of colic in the early stages. As the illness progressed the beast would groan and lie stretched out on its side. Diarrhœa developed in all except the first two fatal cases and became severe. There was no sign of discoloured or blood-stained fæces. Throughout the illness the temperatures were normal or within one degree rise. During the course of the illness seven new cases were detected which had shown no symptoms within the first three days. One of these was the last to die—the eighth fatal case. Treatment consisted primarily of the administration of ferric oxide, and all the cattle, whether they exhibited symptoms or not, were treated at least twice per day from October 23 to 28, but dosing was discontinued after three days in those animals that showed a definite improvement. Affected bullocks were given larger and more frequent doses. Six of the eight bullocks noticed to be ill on October 23 showed an improvement within two days and recovered, while six out of the lot of seven also survived. By October 28th all the bullocks had recovered with the exception of one which lingered and died on November 10. A portion of liver and the abomasum, including its contents from an autopsied case, were sent for analysis to Dr. Tom Hare, who reported as follows: "Approximately 1/85th of a grain of arsenic per ounce was separated from the liver and approximately 1/50th of a grain per ounce was separated from the walls and contents of the abomasum."

TORSION OF THE UTERUS

By CHARLES WEIGHTON, M.R.C.V.S.,
Lincoln

Case 1. A pure-bred three-year-old Friesian heifer in good condition was due to calve on September 30. She had shown restlessness the day before, but no definite signs of calving. An examination on the 30th showed that parturition was prevented by a right torsion of the uterus of half a turn, so that it was only just possible to pass the hand into the uterus and touch the calf. The heifer exhibited little discomfort and her temperature was normal. She was cast and rolled to the right. After three complete revolutions the torsion was reduced. The heifer was then allowed up. Labour pains again commenced. The calf, although dead, was in a normal anterior presentation. Dilatation of the cervix had been delayed as a result of the torsion, so that the exit was not more than three inches in diameter. This part of the procedure was completed at 11 a.m., when an injection of pituitrin was given. At 4 p.m. the cervix was found to have dilated considerably, and with assistance parturition was com-

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pleted. A tear about three inches long unfortunately occurred in the left wall of the vagina, necessitating the insertion of three sutures. A small roll of cotton-wool was then passed into the vagina to arrest the slight hæmorrhage round the cervix, and the vulva sutured with the object of preventing a rapid uterine prolapse. The heifer made a good recovery.

Case 2. A similar case was seen in a Lincoln Red cow a few days later, with a left torsion. In this case the calf had been dead about three days and the cervix was in a particularly rigid state. The torsion was reduced at 8 p.m. An attempt was made to remove the calf then, and again at 11 p.m. An injection of stilbœstrol dipropionate was given at both visits. Owing to the septic condition of the uterus, cæsarean section was contra-indicated. There was little alteration in the state of the cervix next day, and after a prolonged effort at delivery the cow was destroyed.

In both cases I have to thank my former assistant, Mr. George Lindsay, B.Sc., M.R.C.V.S., for his share in the work.

Case 3. A Friesian cow, third or fourth calver. At midday the cow was rolled to reduce the torsion and an injection of pituitrin administered. By 6 p.m. the cervix had dilated to its full extent and the cow delivered of a dead calf.

At what stage of gestation the torsion actually takes place is not always easy to determine, but from a record of one of my cases in 1928 which was being treated for transit fever, and had difficulty in rising for a day before parturition, the torsion occurred some time within the last 24 hours of gestation. A common symptom, and one which is practically diagnostic, is that the vulva has altered in shape, and presents the appearance of being "pulled in, or forward," as distinct from the usual congestion present before calving.

From my earlier experience of torsion of the uterus I found that rupture of the vagina or uterus was not an uncommon sequel, and it is primarily for this reason that a delay of six to twelve hours is suggested after correcting the torsion before delivery is effected.

Since fatal accidents are so liable to occur from the too hasty removal of the fœtus, it is better to have a dead calf than to endanger unduly the life of the dam. A calf that has been dead for 24 hours is invariably emphysematous, and with each hour the chances of a successful operation, even with embryotomy, becomes less hopeful; consequently there should be little delay in the case where it is estimated that the fœtus has been dead for twelve hours, and none if there is any indication of emphysema of the calf or sepsis of the cow.

Experience of recent cases indicates that the administration of stilbœstrol, dipropionate and pituitrin in conjunction, in relatively large doses, especially where an early diagnosis has been made, will prove a valuable aid towards the treatment of torsion of the uterus in the cow.

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